Audit of an Organisation's ICT Systems for Flexible Working

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Abstract: This research entails an audit of the ICT systems within an organisation to determine the environmental impact of flexible working on the organisation's carbon footprint. The study reviews current issues and methodologies in the green ICT sector before providing an overview of the research process. Questionnaires and observations are employed for the investigation on employee working habits. A number of energy consumption measuring tools such as Joulemeter, Powermeter, and SusteIT are used to audit energy consumption of laptops, monitors and phones used by the organisation. This research reveals that working from home has a lower carbon footprint than working in the office primarily due to commuting-related energy consumption. Approximately 20% of the organisation's staff work from home. The organisation's annual carbon footprint is 31,509kg of CO_2 emissions taking into consideration IT equipment and travel-related emissions. The recommendation is to allow more staff to work from home with given guidelines on the responsible handling of IT equipment in order to reduce their energy consumption. It is recommended that further study be undertaken in order to gain a detailed carbon footprint report.

Keywords: technology as an enabler, flexible working, LCA, audit, environmental impact, carbon emissions, energy consumption sustainable tool

1. INTRODUCTION

The ICT sector leads the way in flexible working (Computer Weekly, 26/5/2009). Flexible working is a statutory right in Part 8A and Section 47E of the UK Employment Act 2002[1]. The REC launches Flexible Work Commission[2] to drive practical recommendations to the Government and businesses in 2011 (example of report[3]) while the Flexible Working Regulations[4] are introduced in 2014. The UK government has drawn flexible working guidelines for employers working[5] and code of practice for handling flexible working requests[6]. Some of the cited benefits of flexible working are: increased productivity, reduced CO_2 emissions, and economic savings (Forum for the Future, 2008). Case studies have been conducted to evidence the benefits (e.g. Cisco[7], BT[8], etc…). This research aims to show the methodology and measurement tools employed for auditing the environmental impact of ICT systems used for flexible working within an organisation.

1.1 Background

The ICT audit is conducted in one of the UK's leading financial organisations. Anonymity is maintained due to legal and data protection reasons. However, this research provides useful insight into a typical financial organisation and empirical data that could be used as a reference for a flexible working environment. It has been reported that Brexit may cost the finance industry up to £38bn if the UK quits the single market (BBC News, 2016). The disruption in the markets caused by this may lead organisations in the industry to look for ways to reduce costs. Adopting ICT as an enabler[9] (i.e. Greening by ICT) is one of the ways to reduce energy consumption which leads to reduced costs.

1.2 Aims and Research Objectives

The aim of this study is to evaluate the carbon footprint of the target company's IT equipment deployed for flexible working and help the company understand the environmental impact of its flexible working policy implementation. The following research objectives help achieve the aim:

a. Scope and define goals of the investigation;
b. Conduct a literature review on current climate change and Green IT issues;
c. Conduct a survey on current IT audit methodologies in order to determine the most appropriate method for analysing the company flexible working system;
d. Conduct a survey to gather informative data on the use of the company flexible working system;
e. Conduct an inventory audit of the company flexible working system;
f. Collate data from (d) and (e) to conduct data analysis;
g. Provide recommendations with evidence on how the organisation can reduce its overall carbon footprint with respect to usage of flexible working system and to compare this with current company strategy in order to determine whether the findings complement, supplement or reinforces the company strategy on their Green IT policy.

1.3 Rationale

Why choose this company? The reason for choosing this organisation is that it is one of the largest organisations in its sector in the UK. This means that it has an influence on the industrial environmental impact. It will also contribute a strong proportion of the corporate energy consumption for the UK and on a global level. Having evidence of the overall carbon footprint for flexible working will allow the company to re-examine its current strategy about its inventory and impact on the environment. The company can then make

[1] http://www.legislation.gov.uk/ukpga/2002/22/section/47
[2] https://www.rec.uk.com/news-and-policy/press-releases/archived-press-releases/rec-launches-flexible-work-commission
[3] https://www.rec.uk.com/__data/assets/pdf_file/0014/124052/rec-flexible-work-commission-report.pdf
[4] http://www.legislation.gov.uk/uksi/2014/1398/made
[5] https://www.gov.uk/flexible-working/overview
[6] http://www.acas.org.uk/media/pdf/f/e/Code-of-Practice-on-handling-in-a-reasonable-manner-requests-to-work-flexibly.pdf
[7] http://csr.cisco.com/casestudy/flexible-work
[8] https://www2.bt.com/static/i/media/pdf/flex_working_wp_07.pdf
[9] http://gesi.org/files/Reports/Smart%202020%20report%20in%20English.pdf

decisions on how to progress forward to fulfil its corporate responsibility and reduce its overall IT carbon footprint.

Why choose flexible working? The main reason for choosing a flexible working environment is that it is the organisation's policy to have all of its employee's flexible working and hot desking. The reasons are as follows:

- Hot desking in the office implies less total required desk space since the office does not have 100% capacity all of the time (employees working remotely and employees having time on client site);
- Clean desk policy means there is less security risk in leaving PCs in the building overnight since all portable computers are with the employees.

Secondly, flexible working is a common practice in the workplace and is growing in popularity. It was found in 2010 that 4.2 million people work flexibly in the United Kingdom (UK Government/AEA, 2010) and that number is growing.

Why conduct the study? The following study is relevant for a number of reasons. They are as follows:

(i) Relevance to global emissions:

IT is a growing contributor to energy emissions, and an average figure states 3% (Pattinson & Kor, 2014) of the total UK emissions are from ICT, this is the same as the aviation industry (ibid; Pattinson, 2010).

(ii) Compliance with environmental legislation

The organisation must comply with current environmental related legislation and policy as it is a key player in the global economy. The Kyoto protocol sets a global GHG emissions target and monitors the way in which member nations comply with GHG emissions targets through detailed analysis (United Nations, 2014). UK climate action following the Paris Agreement is to set UK target for reducing domestic emissions to zero[10].

(iii) Corporate and social responsibility

The organisation's corporate and social responsibility is a commitment to improve its own environmental impacts (Pattinson, et. al, 2011) to help mitigate the effects of climate change. Companies in the ICT sector are increasingly enquired of their sustainability efforts and to report on the matter by customers, stakeholders and the government (ITU, 2013). Environmental responsibility is cited as one of the pillars for CSR and a tool for the assessment of Environment has been developed (Bazarhanova, et. al., 2016).

(iv) Cost reduction

To reiterate, some of the benefits of flexible working are: productivity (BIS, 2014); costs (e.g. estate costs[11], recruitment costs[12], etc…) and carbon reduction[13] (through travel reduction[14]).

2. LITERATURE REVIEW

2.1 Flexible Working

The many different forms of flexible working include part-time work, flexitime and overtime[15]. The UK government launches the Anywhere Working online portal[16] to help UK organisations adopt more flexible working practices. Digital technologies (e.g. portable computers, teleconferencing and telecommuting facilities, tablets, smartphones, etc…)[17] have provided the means to effectively support flexible working so as to improve the work-life balance of millions of people[18].

2.2 Green ICT

ICT innovation is viewed as a key element to green growth and sustainable future[19] and undeniable, ICT can improve environmental performance and address climate change[20]. This is made possible by using ICT as an enabler to improve energy efficiency, reduce carbon emissions to mitigate climate change (ibid). However, ICT has both positive and negative effects on the environment (Houghton, n.d.). Some positive effects are: dematerialisation, which is primarily the contribution to reduction of paper use; reduced employee travel which is particularly relevant in this study due to the flexible working stance; overall increase in energy efficiency in production, use and recycling, etc… (ibid); reduced energy consumption due to optimisation where ICT reduces another product's environmental impact due to smart technologies (Vickery, 2012). On the other hand, some of the negative effects are: resource consumption for the manufacture of ICT products (e.g. microchips, batteries, semi-conductors and dangerous chemicals); e-waste; degradation (where ICT devices embedded in non-ICT products lead to difficulties in disposal management such as smart tags, etc… (ibid)); increased energy consumption due to the increased use of ICT to support digitisation of business operations and processes (Frans Berkhout, 2001); rebound effect (Houghton, n.d.).

4. METHODOLOGY

4.1 Scope of the Analysis

In order to perform an audit of the organisation, an initial scope is determined. A number of assumptions and boundaries for the audit and analysis are considered:

- Conducted only for the use phase of the lifecycle;
- Location and time consideration: one of the office sites of the company in Leeds with a staff size of 86 employees; audit is conducted over 8-hour working day over a week;
- Focuses on the client side of the operations, mainly considering the equipment used by the staff. This includes laptops, monitors and mobile devices, along with charging equipment;
- Primary enablers of the ICT equipment.

4.2 Methodology

LCA Methodology

LCA methodology stands for Life Cycle Assessment (ATIS, 2010), and is a common tool in ICT audits. The phases in a LCA methodology for ICT are depicted in Figure 1 and they

[10] https://www.theccc.org.uk/wp-content/uploads/2016/10/UK-climate-action-following-the-Paris-Agreement-Committee-on-Climate-Change-October-2016.pdf
[11] https://www2.bt.com/static/i/media/pdf/flex_working_wp_07.pdf
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[20] http://www.oecd.org/internet/ieconomy/ictstheenvironmentandclimatechange.htm

are: equipment raw material extraction; production; use; equipment end-of-life treatment (ibid; ETSI, 2011). To reiterate, focus of this study is only on the ICT equipment use phase which encompasses both hardware and software. The inputs of the system are: raw materials, energy, and water while the outputs of the system are atmospheric wastes, waterborne wastes, solid wastes, co-products and other releases. For the purpose of this study, the focus for the output will be atmospheric wastes with an emphasis on carbon emissions.

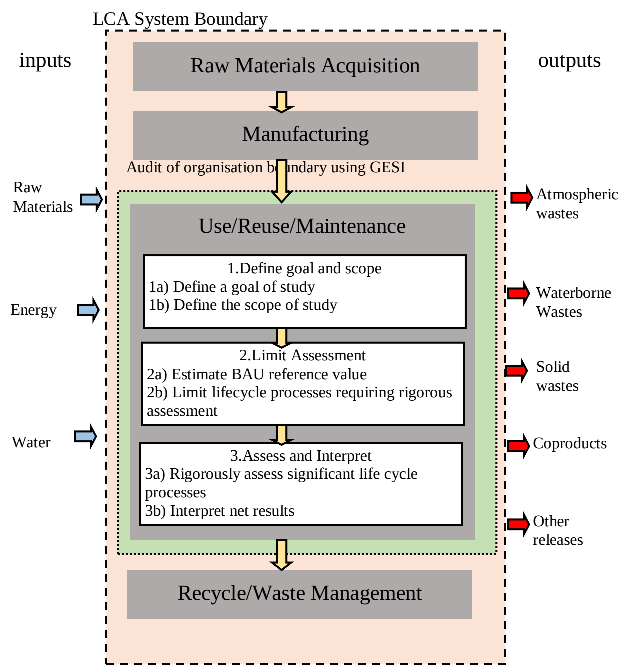

Figure 1: Integrated LCA and ICT Enablement Methodology (ATIS, 2010; GESI, 2010; ETSI, 2011);

Figure 1, depicts an integrated LCA and ICT Enablement Methodology (ATIS, 2010; GESI, 2010; ETSI, 2011). GESI ICT Enablement Methodology comprises the following steps: (i) Step 1: Define goal and scope of study – focus is on the use phase, CO_2 emissions for the output, ICT equipment for flexible working for the organisation's office at Leeds, and audit lasts for a week; Step 2: Limit assessment – this encompasses the estimation of BAU reference values and limitation of rigorous calculations in the lifecycle; Step 3: Assess and Interpret – rigorously assess lifecycle processes followed by interpretation of analysed results.

Micro Methodology

The LCA methodology provides a macro framework for the study. However, the micro methodology comprises a 7-step guide to measuring carbon footprint in ICT (Green Digital Charter, 2014). This is an appropriate method for the audit of the organisation and the steps are as follows:

a. **Organisational Scope:** has been discussed in the preceding section;
b. **Define the Assets:** involves gathering data *x* and number *n* of ICT devices (the assets) for the audit within the scope;
c. **Estimates:** obtain estimates on ICT equipment usage through questionnaires handed out to a sample of 20 employees with flexible working arrangement with the organisation. The estimates are: total annual usage of the ICT equipment (in hours) and the total number of hours the equipment is on standby;
d. **Count/Calculate:** determine how much energy in terms of kilowatt-hours (Kwh) each asset uses in the use phase of the lifecycle;
e. **Convert:** convert the recorded data from Kwh into CO_2 emissions, based on the energy conversion factor grid in the UK (0.5246kgCO_2e per unit)(Carbon Trust, 2011);
f. **Summarise the findings:** prepare a summary of the key findings and present them to the stakeholders of the organisation involved in the audit;
g. **Action Plan:** make recommendations to the organisation for a future action plan.

Audit Tools

The micro methodology involves the use of a number of tools for the 7 steps discussed above. They are as follows:

(i) Duration of Use

Questionnaires: survey on employees' IT equipment energy consumption behaviour and changes they would like make to their current working style;

Measurements: analyse energy consumption and corresponding carbon emissions of Lenovo X1 Carbon laptops used by flexible working employees;

Observations: obtain office data on number of laptops in circulation etc., audit and analyse office capacity and utilisation.

(ii) Energy Consumption Values

Application Energy Consumption - Joulemeter

Application related energy consumption is estimated using free Microsoft Joulemeter software (O'Reilly, 2014). This is applicable for the organisation's Windows laptops. This is part of step (d) of the 7 phase micro study.

Hardware Energy Consumption and Disposal – Powermeter and Document Review

Power and e-waste: Laptop computers use between 15-60 watts of power while an LCD monitor uses 20-40 watts (Bluejay, 1998-2016). The actual figure for Lenovo X1 Carbon is found in its specifications. According to My. Bluejay, laptops are more expensive to repair than desktops so the chemical-laden batteries have to be disposed in compliance with WEEE regulations[21]. The flexible working scheme must consider e-waste since disposal of these batteries will have a detrimental effect on the environment. This is also part of step (d) of the 7-phase microanalysis.

Mobile phone: powermeter: the power consumption for mobile phones could be estimated using power analysers. However, for this audit, its approximate power consumption value is determined using the power meter (Yokogawa, 2008-2016).

Energy consumption calculation: employ Energy Use online calculator[22] to calculate the laptop energy consumption for an office worker once the average usage (in hours) have been determined and this results will be triangulated with powermeter reading;

[21] http://www.legislation.gov.uk/uksi/2013/3113/contents/made
[22] http://www.energyusecalculator.com/electricity_computer.htm

Powermeter reading: used to record reading for a laptop energy consumption (i.e. when charging laptop and using a fully charged laptop).

(iii) Estimate Carbon Emissions

Sustainable IT Tools (SusteIT Tool)[23]: used for carbon emission calculation. Data collected from the questionnaires (usage durations), joulemeter (for applications), hardware power-related specifications, and powermeter are inputs into the Suste-IT tool. The output will be an estimated carbon emission values. Note this is step (e) of the 7-step micro process;

5. Results and Discussion

This section furnishes details of the audit. The results are coded into the following categories: onsite attendance levels to determine the percentage of employees working at home vs. working in the office; equipment usage is considered to determine the average number of hours each piece of IT equipment is used; carbon emissions calculations for each piece of equipment are performed for the office and at home. A comparative carbon footprint-related analysis is conducted for an average office worker and flexible working employee and finally, the estimated total emissions for the organisation is presented.

5.1 Attendance Breakdown

To reiterate, questionnaires are administered to a sample of 20 employees of the organisation. A representation of an average spread of employees working at home and in the office is shown in Figure 2 (note: the sample size, *n*, is 20). These percentages are subsequently mapped to a total of 86 employees working in the department (see Table 1). Working on client site and in other offices are beyond the scope of this study.

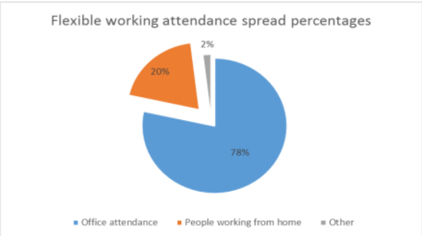

Figure 2: Pie chart for the attendance spread

Data represented in Figure 2 is for a 5 day working week the observational data reveals there is negligible attendance during weekends. The average number of days working in office vs working from home are obtained through the questionnaire. On the average, 3.88 days is spent in the office, 0.93 day at home, and 0.19 day on other sites per working week. Figure 2, therefore, shows a rounded value of 20% of the working week is spent at home. However, there is a total of 86 workers in the office area. The sample percentages from the questionnaire are mapped to the total number of office employees, yielding Table 1. The number of office workers in the office and at home per day is 69 and 17 respectively. Subsequently, the average number of days per week is used in order to estimate the total number of days per year.

Location	Avg. no. of office workers per week (N = 86)	Avg. no. of days per week	Total no. of days per year	Percentage (%)
Office	67	3.88	202	78
Home	19	0.93	48	20
Other	0	0.19	10	2
Total	**86**	**5**	**260**	**100**
N = 86				

Table 1: Inferred number of working days in the office and office for the entire population (N = 86)

5.2 Inventory

An inventory list for the audit is obtained from: asking all the employees (N = 86) whether they have a work laptop and work mobile phone; observation for the total number of monitors in the office (note: the researcher is a staff employee so he has access to information about the equipment). Table 2 shows the inventory list for the audit.

Equipment type	Equipment Model	Numbers of each piece of equipment
Laptop	Lenovo X1 Carbon	86
Monitor	Lenovo ThinkVision LT2252p 23"	60
Phone	iPhone 6	86

Table 2: Inventory List for the Audit

5.3 Equipment Usage

After having estimated the organisation's office staff's attendance and the inventory list for the audit in the preceding section, data about the usage of each piece of equipment (in hours) is required for the use phase in the lifecycle. Once again, this piece of data is obtained from the employee survey. Three types of equipment considered for the analysis are: employee laptops, mobile phones, and client-side monitors (see Table 2). Average usage hours per week per device is calculated based on collated questionnaire data (n = 20), followed by an estimation for the entire year. For the laptop, employees are asked to give the average number of hours their laptops are in use and left on standby per day. As for the monitor usage, it is assumed that whilst in the office, all workers are connected to their desk monitor and the usage is assumed to be the same. The phone consumption data is found by understanding the amount of time a phone is being charged (Yokogawa, 2008-2016). Employees are therefore asked how many hours they charge their phone per day. The data for the equipment usage in hours per year is shown in Table 3.

Equipment type	Avg. hours of usage per employee per year	Avg. hours standby per employee per year
Laptop	1470.33	807.24
Monitor	1470.33	807.24
Phone	916.19	1.00

Table 3: Estimated Average Equipment Usage per Employee per Year

It can be seen that the average number of standby hours for each employee is over 50% of the total use hours. This is due to a small percentage of individuals leaving their laptops on standby overnight, thus bringing the average value up.

5.4 Energy Consumption

Next, it is necessary to understand the energy consumption of all the three types ICT equipment under study. A range of

[23] http://www.susteit.org.uk/files/

tools are employed to provide information on their power consumption: powermeter, Joulemeter and review of equipment's specifications.

Laptop: The total power consumption (during idle, active, and standby states) for the laptop is measured using a power meter. These readings are measured in the office and at home, and with the laptop on and off charge. The results are shown in Table 4.

Location	PC description	Quantity	Power at ACTIVE (W)	Power at SLEEP (W)	Power at IDLE (W)
Office site (fully charged)	Lenovo X1 Carbon	1	14.6	7.9	8.1
Researcher home (fully charged)	Lenovo X1 Carbon	1	14.6	7.8	8.7
Office site/Home (on charge)	Lenovo X1 Carbon	1	61.0	60.0	60.8

Table 4: Powermeter readings for the Lenovo laptop

The results in Table 4 shows that the laptop's power consumption when on charge is approximately 4 times larger than the power consumed when it is active and on charge. No power is saved when on standby if the laptop is on charge. Values for home and in the office are similar for a fully charged laptop.

Joulemeter is used to provide insight into the power breakdown of different components for a laptop in use (see Figures 3 and 4).

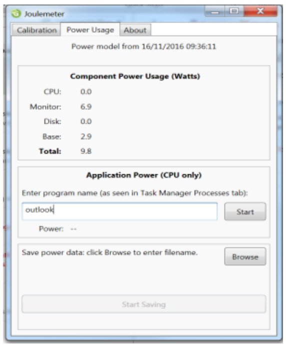

Figure 3: Screenshot of the Joulemeter Interface

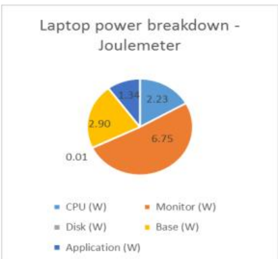

Figure 4: Power Consumption Breakdown for Laptop

The total laptop's power usage (when fully charged) measured by Joulemeter is 13.23W which is quite similar to the reading of the power meter in Table 4. It can be seen that most of the power (i.e. approximately 50%) for the laptop is consumed by the monitor.

Monitor and Phone: Active and standby power for the monitor and phone are obtained from their specifications (i.e. monitor (Lenovo, 2016), and phone (gsmarena, 2000-2016)). Their respective values are tabulated in Table 5.

Equipment	Active power (W)	Standby power (W)
Monitor	20.0	0.5
Phone	6.9	1.0

Table 5: Power Consumption for Monitor and Phone

5.5 Carbon Footprint Calculation – Suste-IT Tool

The attendance data, equipment usage and energy consumption are used as inputs for the Suste-IT tool (SusteIT, 2008) to calculate an office and home worker's carbon footprint.

Office worker: For an office worker, the carbon footprint investigation encompasses equipment usage, travel to and fro from the office. Results of equipment usage per office worker per year have been analysed using Suste-IT tool (see Table 6). It can be seen that the ICT equipment average annual energy consumption for an office worker is 64.14. kWh.

Equipment	Number	Active, Idle Power, W	Standby Power, W	Active, Idle Hours/year	Standby Hours/year	kWh/year per unit	Total kWh/year
Laptop (office)	1	14.60	8.10	1470.33	807.24	28.01	28.01
Monitor (office)	1	20.00	0.50	1470.33	807.24	29.81	29.81
Phone (office)	1	6.90	1.00	916.19	1.00	6.32	6.32
Total							64.14

Table 6: Equipment Usage per Office Worker per Year

Next, we shall investigate an office worker's daily commute travel-related carbon footprint. The questionnaire results for the types of transport utilised by office workers are shown in Figure 5 where 20% comprises cycling or walking.Three other modes of transport that contribute to CO_2 emissions are considered. The average mileage per office worker is calculated for each effective mode of transport followed by the calculation of each respective carbon footprint (see Tables 7 and 8). Once again, the data for this study is obtained from the questionnaire results.

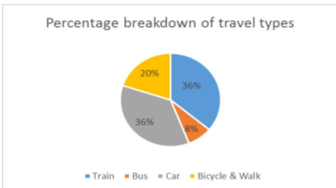

Figure 5: Breakdown of Travel Type for Office Workers in the Organisation

The average annual carbon footprint for each office worker is calculated using the CO_2 emission/ passenger mile (kgs) provided by Carbon Fund[24]. It is noted that the carbon footprint for an average car is the highest while it is the lowest for a bus travel.

Home Worker: The same process for calculating the carbon footprint of a home worker is similar to that of an office worker without travel. Results are shown in Table 9.

Based on results in Tables 6, 8 and 9, a comparative analysis of the carbon footprint for an office worker and home worker is shown in Table 10. The default value used by Suste-IT tool for CO_2 emission (kg CO_2/kWh) is 0.537 (i.e. for ICT equipment usage). Results show that the carbon footprint for a home worker is very much less than that of an office worker. It is less than 5 times than office worker that

[24] https://carbonfund.org/how-we-calculate/

commutes by bus and approximately less than 40 times compared to an office worker who drives to work.

Mode of Transport	Average weekly mileage per office worker (miles)	Total weekly mileage for office workers (miles)	Annual mileage per office worker (miles)	Total annual mileage for office workers (miles)
Train	48	1413	2484	73469
Car	42	1232	2167	64071
Bus	20	131	1040	6834
Total	110	2776	5691	144374

Table 7: Mileage for Different Modes of Transport per Office Worker

Mode of Transport	Annual mileage per ofiice worker (miles)	CO2 emission/ passenger mile (kgs)	Annual CO2 emission (kgs/y)
Train	2484	0.170	422.28
Car	2167	0.360	780.12
Bus	1040	0.055	57.20

Table 8: Carbon Footprint for Different Modes of Transport per Office Worker

Equipment	Number	Active, Idle Power, W	Standby Power, W	Active, Idle Hours/year	Standby Hours/year	kWh/year per unit	Total kWh/year
Laptop (home)	1	14.60	8.70	1470.33	807.24	28.49	28.49
Monitor (home)	0	n/a	n/a	n/a	n/a	n/a	0.00
Phone (home)	1	6.90	1.00	916.19	1.00	6.32	6.32
Total							34.81

Table 9: Equipment Usage per Home Worker per Year

	Travel	Equipment Use	Total
	Annual CO2 emission (kgs/y)		
Office Worker (Train)	422.28	34.44	456.72
Office Worker (Car)	780.12	34.44	814.56
Office Worker (Bus)	57.20	34.44	91.64
Home Worker	0.00	18.70	18.70

Table 10: A Comparison of Carbon Footprint for an Office and Home Worker with Different Modes of Transport

Organisational totals

Table 1 and the breakdown for travel type in Figure 5 are used to estimate the overall organisational carbon footprint for flexible and office working. The results are presented in Table 11. Results reveal that a single office in the organisation has a carbon footprint of approximately 31,509.86 kgs CO_2e per year (due to ICT equipment use and ICT as an enabler). An average carbon footprint of a home worker is approximately 18.7 kgs CO_2e/year while it is 465.0 kgs CO_2e/year (i.e almost 25 times higher) for an office worker.

	Travel	Equipment Use	Total
	Annual CO2 emission (kgs/y)		
Office Workers (Train)	10185.39	830.78	11016.17
Office Workers (Car)	18816.49	830.78	19647.27
Office Workers (Bus)	306.59	184.62	491.21
Total for Officer Workers (n=67)			31154.66
Home Workers (n=19)	0.00	355.21	355.21
Total for Organisation (N=86)			31509.86

Table 11: Estimated Carbon Footprint for Office and Home Workers within the Organisation

6. RECOMMENDATIONS and CONCLUSIONS

A number of conclusions can be drawn from the audit. Firstly, it can be seen that flexible working a greener method of working for employees. The biggest saving in carbon emissions for the home worker is the absence of travel. Driving a car to work seems to have the highest carbon footprint. Secondly, power consumption for a laptop on charge 61.0W, which is approximately 4 times the amount for a laptop working fully charged at 14.6W. This means working from the battery is a greener method of using the laptop. The laptop study also showed that a small percentage of workers left their laptops on standby overnight. This causes a significant rise in the average standby hours for the group studied. There are a number of limitations to this study. The study does not cover the entire lifecycle of the IT equipment, and it does not include other IT equipment in the office so that a fair comparison could be made between an office and home worker. Similarly, energy consumption for running an average home for electricity and heating etc. is not considered.

The results from the study have allowed support a recommendation for improving the organisation's overall flexible working strategy to reduce its carbon footprint. An increase to the number of staff working from home would mean a reduction in the organisation's overall carbon footprint. The company also ought to look into mode of transport used by its employees to commute to work.

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